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THERMAL PERFORMANCE AND DELIVERY CAPABILITY OF A 310 L ELECTRIC WATER HEATER FOR DAIRY USE

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Test results are presented for an electric water heater which is designed for use in dairies. The tank has a unique coiled diffuser which is claimed to stop sediment from settling on the bottom. When tested in accordance with selected clauses of the CSA Performance Standard for Electric Water Heaters, the tank fell slightly short of most of the requirements.

INTRODUCTION

Standard residential electric water heaters are normally designed to operate at or below 60°C. Dairy farms require higher temperatures for cleaning of milk handling equipment.

A United States manufacturer has produced a tank which is designed for the higher temperature conditions required for dairies. The tank has a top inlet (dip tube) for the cold water, and a coiled inlet diffuser which creates turbulence inside the tank, and is claimed to stop sediment from settling at the bottom.

A 310 L (nominal) model of one of the above tanks was tested. The results are presented in this report.

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TEST METHODS AND INSTRUMENTATION

The following tests described in the January 1990 draft of CSA Standard C191, "Performance of Electric Storage Tank Water Heaters", were performed to establish the thermal performance and delivery capabilities of this water heater: Tank Capacity (Clause 5.4), Energy Efficiency (Clause 5.6), Delivery (Clause 5.11), Diffusion (Clause5.7), Upper Zone (Clause 5.10), and Heating Element Input (Clause 5.5).

All tests were performed at the OHRD Water Heating Test Facility. Although the tank is designed to operate at higher than standard temperatures, the tests were conducted according to the standard requirements for residential water heaters. There is no standard for this type of tank.

Tank temperatures, water flow rates, and electrical energy consumption were recorded, verified, and stored in machine readable form for analysis.

TEST RESULTS AND DISCUSSION

Table 1 summarizes the results of the tests performed. Test results in more detail are found under the respective subheadings.

Tank Capacity Test

The tank capacity was measured using a nutating disk flow meter. Total volume at line pressure was 311 L. The CSA standard stipulates that the tank volume must be within +7%, -0% of its stated capacity. For this reason, to meet CSA Standard C191, this tank can officially be labelled a 289 to 311 L model.

Energy Efficiency (Standby Loss) Test

The energy efficiency test results are graphically illustrated in Figure 1. The standby loss for this tank was 120 W. The new CSA standard allows for a loss of up to 134 W; consequently, this tank passed the requirements of this test.

Delivery Test

The hot water delivery requirements were not met by this tank. The tank was unable to maintain the standard delivery temperature when subject to 16 daily withdrawals totalling 635 L (Table 2). The thermostats of the tank were set for a 56°C rise above the inlet temperature of 4°C, as required in the standard. A water heater is deemed to have failed a delivery schedule if the difference between the average outlet temperature and the inlet temperature drops below 44°C, except that one draw may drop to 39°C above the inlet temperature. Figure 2 is a differential graph which shows the average outlet temperature minus the inlet temperature (*outlet temperature rise*) during the draws.

Table 1
310 Litre Tank Test Results

Test Name and Clause	Test Requirement	Test Result	Pass/Fail
Tank Capacity (Clause 5.4)	N/A	311 L	N/A
Energy Efficiency (Clause 5.6)	< 134 W	120 W	Passed
Delivery (Clause 5.11)	See "Delivery Test" Subsection		Failed
Diffusion (Clause 5.7)	90% (280 L)	84% (261 L)	Failed
Upper Zone (Clause 5.10)	33 ± 2.5% (103 ± 7.8 L)	13.8% (43 L)	Failed
Heating Element Input (Clause 5.5)	Upper/Lower 4500 ± 5% (225 W)	4620 W/ 4579 W	Passed/ Passed

Diffusion Test

The diffusion test indicated that the percentage of the total tank volume of delivered hot water before the outlet temperature dropped 17°C below the setpoint was 84% (261 L). The minimum requirement for this test is 90% (280 L). Consequently, the tank failed this test by 19 L. Figure 3 shows the results of this test graphically.

Upper Zone Test

The upper zone test determines the volume of water heated by the top element. The test was conducted on a cold tank with the lower element disabled. The upper element was operated until cycling off thermostatically. The thermostat was set for a 56°C rise above the inlet temperature. Water was drawn off at 18 L/min, until the outlet water temperature dropped 17°C below setpoint. Figure 4 shows that 43 L (13.8% of the total tank capacity) of hot water were provided by the tank before the discharge temperature declined 17°C. The CSA requirement is 33 ± 2.5% of the tank volume for a 270 L tank; in this case 103 ± 7.8 L. This tank failed the CSA requirement. Lower placement of the upper element should improve the performance for this test.

Heater Element Input Test

Heater element input was measured for both elements. The measured power inputs to the upper and lower elements were 4620 and 4579 W respectively. Both elements passed the CSA requirement of 4500 W $\pm$ 5% (225 W).

CONCLUSIONS

When tested in accordance with selected clauses of the CSA Standard C191/1990:

1. The tank met the standby loss requirements of the 1990 version of the standard.

2. The tank failed to meet the delivery requirements as set out in the standard.

3. The tank failed the diffusion requirements of the standard.

4. The tank failed the upper zone test.

5. Both elements passed the power input test.

Note: Because there is no standard for dairy electric water heaters, a test specification should be developed based on the CSA Standard C191. However, considering that the tank failed some of the requirements for residential water heaters, it is not likely that it will meet the new requirements for higher temperature settings. Some design modifications and a new test are recommended.

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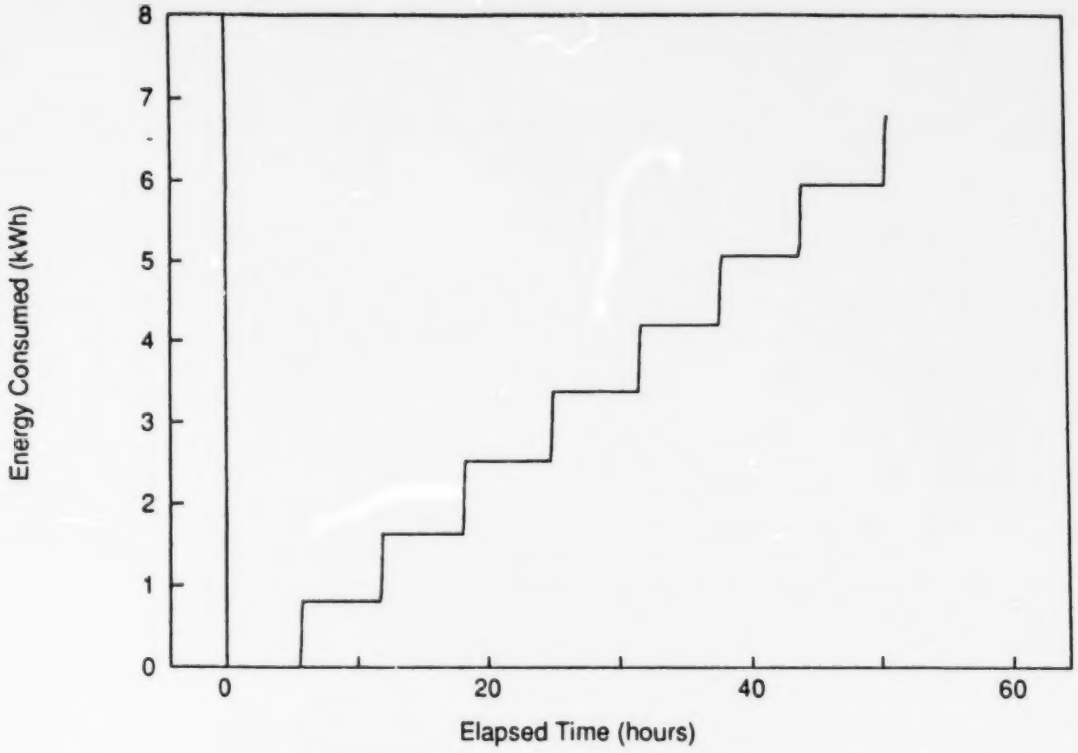

Figure 1 - Energy Efficiency Test

Table 2 - 635 Litre Delivery Schedule

Withdrawal Number	Elapsed Time (hours)	Withdrawal (litres)
1	0	57
2	1	57
3	2	64
4	3	127
5	3.5	114
6	4	70
7	5	19
8	6	19
9	7	19
10	8	7
11	9	19
12	10	13
13	11	12
14	12	19
15	13	13
16	14	6

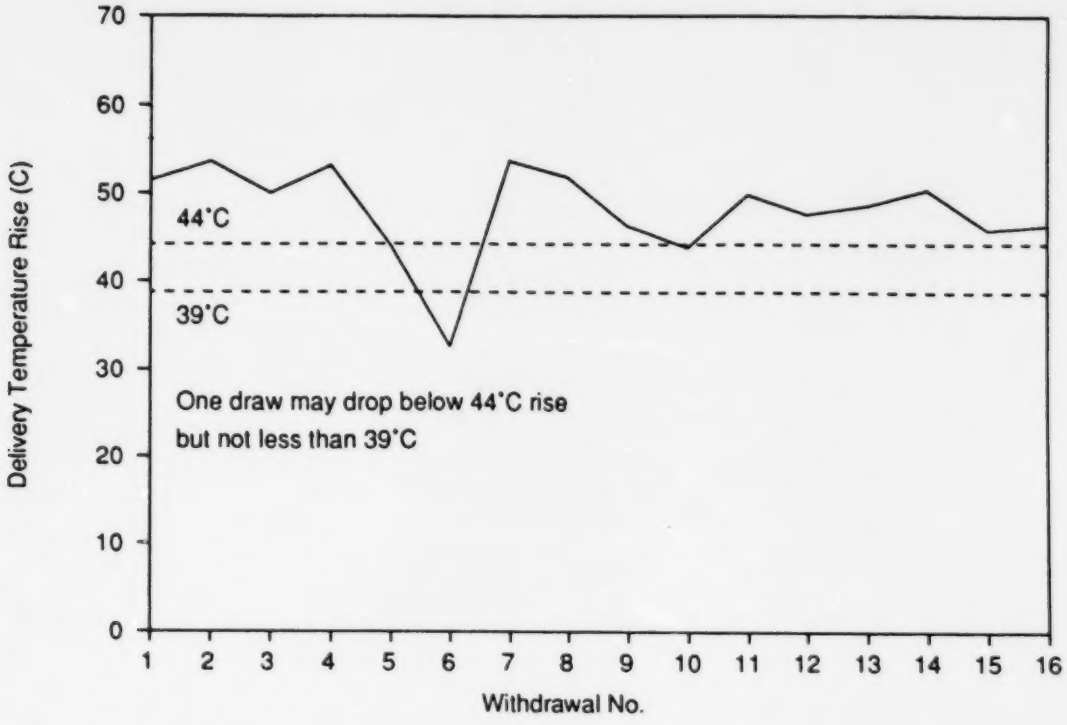

Figure 2 - Delivery Test

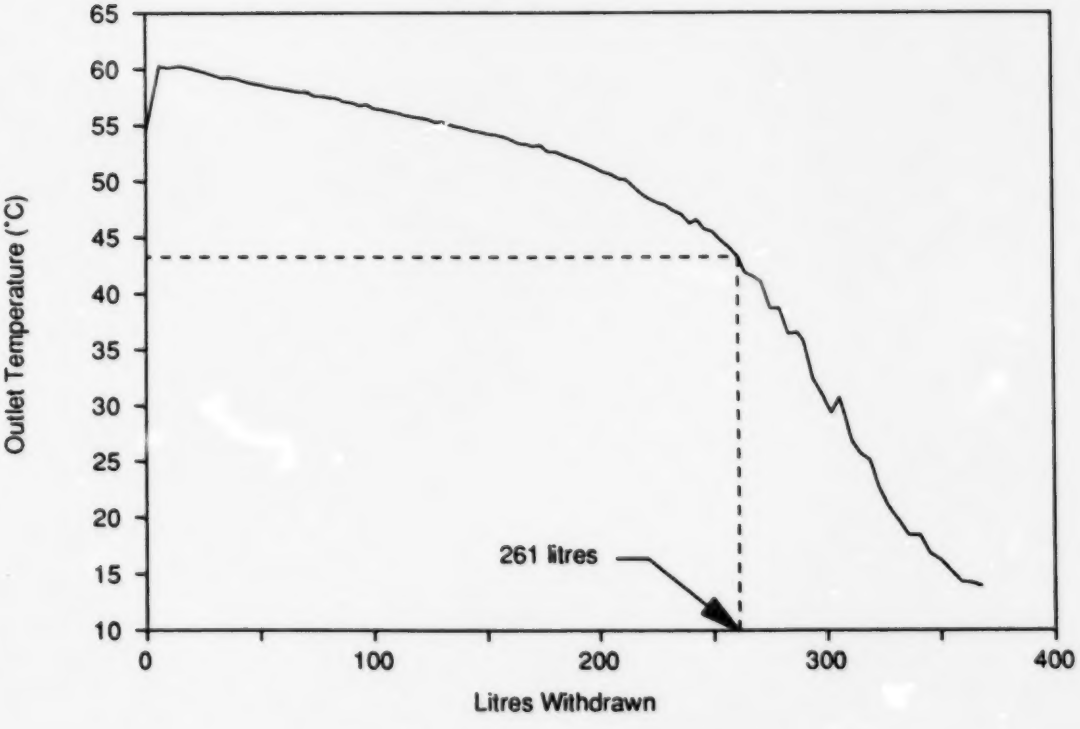

Figure 3 - Diffusion Test

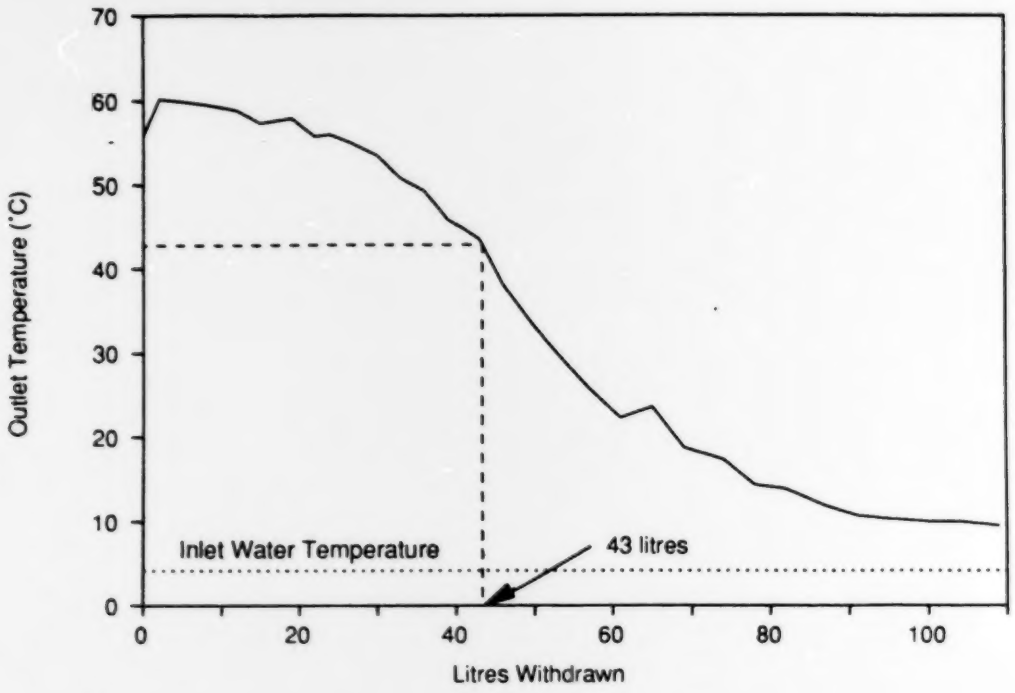

Figure 4 - Upper Zone Test